11.4 SURFACE WATER FLOW MEASUREMENTS

11.4.1 General

Surface waters are considered to be open channel for flow measurement purposes. All of the techniques used by DEQ personnel to measure open channel flows have been discussed in the wastewater flow measurement portion of this section. Except for very small surface streams, the installation of primary flow devices is not practical. Most surface water flow measurements are made using classical stream gaging techniques. These techniques involve the use of the velocity-area open channel technique discussed in the waste-water portion of this section. DEQ personnel shall use the techniques outlined in the USGS publication Discharge Measurements at Gaging Stations (9) to:

- Select the flow measuring site;
- Perform stream gaging; and
- Calculate flow.

11.4.2 Techniques

Where possible, DEQ stream studies shall be conducted utilizing the existing permanent stream gaging stations operated by the USGS, the U. S. Army COE, or other federal or state agencies. These permanent gaging stations have established water stage-discharge relationships that permit the flow to be obtained from water stage measurements. Staff gage or recorder readings of a water stage at these stations may be converted to flow by using the rating curve for that gaging station. The rating curve is available from the operator of the perm anent gaging station. An additional benefit of using these permanent gaging stations is that long-term flow records are generally available.

Where permanent gaging stations are not present, surface water flows shall be measured utilizing classical stream gaging techniques. If a station is to be used more than once during a water quality survey, a rating curve shall be developed for that station. This may be done by making a series of independent flow measurements and simultaneous tape down or staff gage measurements for that station at different water levels. The rating curve is developed using the same measurement section each time; at least two, and preferably three, flow measurement - tape downs shall be made. The flow measurements used to develop the rating curve must bracket the lowest and highest flows encountered during the study. A tape-down rating curve is constructed by plotting the tape-down measurements versus flows on a piece of semi-log graph paper.

11.4.3 Equipment Available (USGS National Handbook)

Equipment available to DEQ personnel for the measurement of surface water or wastewater flows is categorized as follows: water level/stage hardware and recorders, velocity measuring equipment and assemblies, and direct flow measurement equipment and instrumentation.

The hardware available to DEQ personnel to determine the rise and fall of a water surface with time (the water stage) includes the following recording devices: Stevens Model F horizontal drum recorders and Stevens Model A-71 continuous strip chart recorders, ISCO Model 1870 recording flow meters used in the linear head mode, and ISCO Model 2870 recording flow meters that have programmable functions. Non-recording equipment available includes vertical staff gages and tape-down systems.

Instruments and equipment available to make velocity cross sectional area measurements include current meters and sounding (depth) equipment. The current meters available to DEQ personnel are the vertical-axis mounted Price AA and Price pygmy meters (including direct readout meters), and Marsh-McBirney solid state current meters. Sounding (determination of depth) is accomplished using a standard top setting wading rod. Width measurements are made by DEQ personnel using a conventional surveyor's tape.

The equipment available for direct flow measurement includes the following primary devices available for installation by DEQ personnel: V-notch weir plates and rectangular weir plates. Corresponding conversion of water level to flow rate can be accomplished instantaneously from stage/staff gage readings corresponding to the primary flow device in use, or by instantaneous readings of the available recording flow meter systems. Continuous recording systems available are the ISCO Model 1870 and 2870 recording flow meters.

11.4.4 Surface Water Flow Measurements (Streamflow)

11.4.4.1 Flowmeter

McBirney Model 201

NOTE: Other stream flow measuring devices include the Price AA meter and the pygmy meter. The pygmy meter is most useful for streams with low discharge.

A. EQUIPMENT

1. Marsh - McBirney Model 201 Portable Water Current Meter

2. Flow meter wading rod, calibrated in one-tenth foot intervals

3. Flow data sheets (Section 21.1.1.5) and clip board (with cord to put around the neck)

B. PROCEDURE

1. Set the selector switch to the "CAL" position. The meter shall show black (the calibrate sector of the scale) if the batteries are good and the instrument is working properly.

2. Attach the probe to the wading rod, making sure the clamp screw is tight and the probe is properly positioned (the clamp screw is vertical).

3. Select a stream section where flows are mostly parallel, where there are no sharp turns in water direction, and the bottom is reasonably smooth. The more uniform a channel is in depth, velocity, and substrate size, the more accurate the velocity measurements shall be. The section can be smoothed by reshaping the edges, removing rocks from the bottom, and removing branches, weeds, or grasses.

4. Set a tag line or cloth tape across the section as perpendicular to flow as possible. Anchor both ends securely to wooden stakes, trees, shrubs, or anchor with rocks or other large or heavy objects.

5. Begin measurements at either the left or right bank. The initial point is generally the tape reading of the waterline and often has no depth or velocity to measure. In this case, the first measurement is made at the first point where there is adequate depth (at least 0.2ft) and measurable velocity. Measurements (depth and velocity) can, at times, be made at one or both waterlines. In other situations, there may be no flow for some distance from the streambank due to stagnant water or backwater effects. In such a case, begin and end measurements in the verticals in the no velocity zone at the edge of where positive flow can be measured.

6. Water depth is determined from calibrations on the wading rod (three marks = 1 foot intervals, two marks = one-half foot intervals, one mark = one-tenth foot intervals); read depths ignoring the "pile-up" effect of water on the wading rod.

7. Velocity is measured at six-tenths depth from the water surface by moving the probe support so that the foot indicator marks align with the proper scale reading (in hundredths of a foot). Care must be taken to keep the meter pointed directly into the flow and to keep the rod in a vertical position. Wait at least 20 seconds before reading the panel meter. Because flow velocity usually fluctuates, the recorded velocity shall usually represent an "average" of the range of velocities noted during the measurement period.

8. Switch the selector switch to the proper velocity range (2.5, 5, or 10 feet per second) as conditions require.

9. Measurement points are best set at whole foot or half-foot intervals, depending on stream width.

C. PRECAUTIONS

1. The limit for wading is set by safety considerations. The amount of water that can be waded safely varies slightly with each individual, but is principally a function of velocity, depth, and substrate stability and slickness. Do not take chances in gauging " unwadable" streams.

2. The position taken when making wading measurements can affect the velocity of the water passing the current meter. The best position is usually about 1 to 3 inches downstream from the tape, and eighteen inches or more from the wading rod, holding the wading rod at the tag line, and standing in a position facing the bank.

D. QUALITY CONTROL

1. Because flow is not a direct measurement (velocity, depth, width, and area are measured first), the accuracy of the method cannot be determined. With selection of good cross sections, and careful measurements of depth and velocity, measured flow shall be within 15% of true flow.

2. Precision of the method (and technique of the investigator) can be determined by measuring total flow several times along the same cross section.

3. Peak instrument performance can be ensured by conducting the periodic maintenance tasks detailed in the Instruction Manual. These tasks include cleaning of the probe, checking the meter zero, and checking the condition of batteries.

E. SPECIAL INSTRUCTIONS

1. Because total flow determination in an open channel is a summation or integration process, the overall accuracy of the measurement is generally increased by increasing the number of partial cross sections. Generally, 25 or 30 cross sections, even for extremely large channels, are adequate depending on the variability and complexity of the cross sectional shape and flow patterns. With a smooth cross section and good velocity distribution, fewer sections may be used. Partial sections shall be spaced so no partial section contains more than 10 percent of the flow. The ideal measurement would have less than 5 percent of the flow in any one section. This means that measurement points are closer together in the deeper and faster parts of the stream and spread out in the shallower and slower parts of the stream. On small streams, a spacing of 0.5ft or less may be necessary, and there may be less than 20 measuring points.

2. Occasionally, flows are not perpendicular to the established cross section for its entire width. If high or low flows change flow patterns at an established cross section, consideration shall be given to temporarily or permanently moving a cross section rather than using a substandard, established one.

3. The following example demonstrates the calculations made using the mid-section method of measurement. The mid-section method assumes that the velocity at each sampling point represents the mean velocity in the partial rectangular cross sectional area. The partial area extends laterally from half the distance from the preceding meter location to half the distance to the next, and vertically from the water surface to the stream bottom.

F. PROJECTS

NPDES Compliance Monitoring, Clark Fork Basin Study,
Intensive Surveys

11.4.4.2 Stick Method

A. Procedure

1. Find a reach of stream that is fairly straight, as well as uniform in width and depth. This will assure that laminar flow is achieved to the greatest extent possible.

2. Measure the length of the reach (in feet) and mark each end.

3. Determine mean width (from the waters edge) by taking at least three transects within each reach.

4. Determine mean depth by measuring depth at multiple points throughout the reach.

5. Release a small stick or other floating object at the top of the reach and count the seconds to reach the lower point. Assure that the object stays in the main current. Repeat at least twice.

B. Calculation

1. Mean width x mean depth = cross-sectional area (ft^2)
2. Convert stick float time to ft/second
   (i.e., 26 ft/15 sec = 1.7 ft/sec)
3. Determine CFS (1 x 2).

Note: This method tends to underestimate flow somewhat due to the slower velocity of water near the surface. However, it is a good general estimate of flow.

11.4.5 References for Water Flow Measurements (From National Handbook of Recommended Methods for Water-Data Aquisition)

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